50X1-HUM

CAUSES OF LOSSES IN WINTER GRAIN IN THE CENTRAL CHERNOZEM BELT

Agrobiologiya, No 5, 1948

50X1-HUM

3 May 1950

CONFIDENTIAL

CAUSES OF LOSSES IN WINTER GRAIN IN THE CENTRAL CHERNOZEM BELT

M. T. Timofeyeva - Tyulina

Loss of winter grain is a rather frequent occurence in agriculture. According to the data of I. I. Tumanov (1940), the greatest loss of winter grain occurs in Ukrainian SSR where the average loss for several years came to 28 percent of the total seeded. In Tatar ASSR this loss came to 16 percent; in Gor'kiy Oblast, 11.5 percent; in Voronezh and Kursk Oblasts, 9.5 percent.

Several scientists explain winter loss of crops by the physico-chemical nature of the protoplasm, by the mechanical damage to the plant cells by ice crystals (Maksimov). Others say that the destruction of the plant under the icy crust is caused by self poisoning due to the formation of alcohol (Rikhter), by suffocation (Mosolow). Tumanov attributes the crop losses to the exhaustion and freezing of the plants.

Works of the Ukrainian and Saratov Institutes of Grain Management and the Kamenniy-Steppe Experimental and Selection Station have shown that the principal losses to winter grain occur from the action of low winter and spring temperatures. Especially harmful are the low temperatures that follow a thaw. The loss of winter wheat during somewhat higher temperatures after a thaw and the wheat's resistance when drier conditions precede the thaw has not been determined. Some scientists attribute the spring freezing of the plants to a loss in the plant's hardening and to the possibility of the plant's passing through the stage of vernalization; other scientists (Tumanov), to the exhaustion of the plant, particularly, to the reduction of soluble carbohydrates.

Experiments in the study of winter-resistant wheat conducted by the former Kamenniy Steppe Experimental Station (Institute imeni V. V. Dokuchayev) show that the principal losses of grain crops under the conditions of the central chernozem belt occur as a consequence of the frosts following a thaw. Especially harmful were the late spring frosts after the growth of the plants had begun. Such an occurence can in no way be explained by the theory of exhaustion since the plants, which usually started their growth in the spring, were strong and vigorous.

The Method of Conducting Experiments

The cold-resistant capacity of winter wheat and rye was studied by the Institute of Agriculture of the Central Chernozem Belt imeni V. V. Dokuchayev, both in green houses and under field conditions of grass-crop rotation. At the same time cold-resistant crops were studied at the Talovskiy State Sorting Point (Sortouchastok) and in a number of kolkhozes of Talovskiy Rayon.

Research was conducted in 1946/47 on the sowing of elite varieties on fields protected by shelter belts and on the open steppe. Winter wheat, Gostianum 0237 was sown on 30 August on the steppe and on 26 August on the fields protected by the shelter belts. Winter rye VSKhI was sown in field No. 2 of elite crop rotation on 18 August; and type Mup in field No. 3 of southern crop rotation on 16 August. The fields were surrounded by recently planted shelter belts.

In this experiment the following problems were studied:

1. What were the pecularities in the condition of the winter grain plants in the winter-spring period?
2. Why did the winter wheat survive the drier conditions of winter and perish during the more humid conditions of spring?
3. Why should one type be more, and another less, cold-resistant under the same growing conditions?
4. What physiological requirements ought to be produced in a type by selection during the appraisal and rejection of plants in the process of determining the most cold-resistant type of winter wheat?

The sowing was done by tractor disk seeding on the steppes and in the fields protected by the shelter belts. VSKhI and Mup rye were sown at the rate of 100 kilograms of seed per hectare; and Steppe 135 and 0237 Gostianum winter wheat, at the rate of 140 kilograms per hectare. The sowing was done in fallow chernozem. Manure was added only to the steppe fields and at the rate of 20 tons per hectare.

Although the young shoots were frail, subsequent rainfalls guaranteed good growth to those plants on the fields protected by the shelter belts, and these took root well and bushed out. On the open steppe where 0237 Gostianum winter wheat was sown in winter, since the ground had not been broken, sowing was worse. This was explained by the severe drying of the plowed lands during the 1946 drought.

Frosts on the ground's surface appeared on 1 October of the year of sowing. On 17 November the temperature dropped to 16 degrees below zero (all readings centigrade). There was a subsequent rise in temperature to 10 degrees above. On 22 November the temperature dropped to 22 degrees below and then rose to 4 degrees above. From the second half of October, the portion of the plants above the earth's surface began to die.

An analysis of the temperature and the number of hours of daylight from 15 August 1946 through June 1947, according to data of the local meteorological station, shows that the duration of the period with a mean daily temperature below zero was 140 days. The number of days with a minimum ground surface temperature below minus 20 degrees was 25 days; below minus 25 degrees, 14 days; below minus 30 degrees, 5 days. Most days with low temperatures ~~fell~~ came in January and February, ~~and most of these cold days came~~ usually after there ~~was~~ had been a snow cover. The number of days with a ground surface (above the snow) and air temperature from zero to ten degrees above, before the actual beginning of the calendar winter, was 45 days. According to ~~our~~ the author's measurements, at the beginning of winter, the difference between the temperature of the ground at the root level and at the surface, without a snow cover, was as much as 2 or 3 degrees. The temperature of the ground at the surface was lower than the temperature of the ground at the root level. Taking the above factors into consideration, one can assume that, before the beginning of the 1946 winter, all conditions were favorable for the winter grain plants, which were planted at the normal time, to pass through the stage of vernalization.

The ground froze after 4 December. The ground was covered by snow from 20 December through the middle of March. The height of the young plants was 13-15 ~~cm~~ centimeters on the steppes and 25-30 cm in the fields protected by the shelter belts. The temperature of the air and of the ground at the surface fell from 18.5 degrees below zero to 20 degrees below zero in November, and to 29 degrees below zero in December. These dates coincide with the snow-free period in November and with the negligible snow cover in December.

An increase in temperature during the winter period was observed from 22 through 28 February. The maximum temperature for this period, according to data of the meteorological station, did not exceed 2.2 degrees above zero. In February, as a result of melting snow and ground thaws of up to 4-5 cm in many places, the plants were exposed. The whole of the primary sown area remained covered with snow. In the places where the ground was exposed, the temperature rose to 10 to 13 degrees above zero in the daylight hours during the thaws.

Melting of the snow began from the second half of March and continued through 25-28 March. By 5 April, the soil was completely thawed on the fields protected by the shelter belts; and by 10 April, on the steppes.

Yearly precipitation from 1 May 1946 through 1 May 1947 was 326.2 ~~mm~~ millimeters, of which 274.8 mm came in the form of rain and 51.4 mm in the form of snow. The number of daylight hours from 15 August through 22 October diminished from 15 to 10 hours; from 22 October through 7 November, from 10 to 9 hours; from 8 November through 22 November, from 9 to 8 hours; from 23 November through 6 December, from 8 to 7 hours. After 7 December and up to 7 January, the number of daylight hours remained at 7 hours. From 8 January, the daylight hours increased and reached 8 hours on 22 January. From 23 January through 7 February, the number of daylight hours increased from 8 to 9 hours; and from 8 through 21 February, from 9 to 10 hours. From 22 February, the number of daylight hours exceeded 10 hours, reaching 15 hours on 1 May.

Warm weather set in from the second half of March to April. The temperature at the ground's surface rose to 18 degrees above zero, with a minimum temperature of 2.3 degrees above and a 25 hour mean of 7 or 8 degrees. During the day, the temperature rose to 15 or 20 degrees above zero. Infrequent drops in temperature to 8-10 degrees below zero were observed in April and May.

The study of winter wheat and rye conducted on the institute's fields utilized an analysis of the condition of the plants for the entire winter and spring periods. Observation of winter crops under kolkhoz conditions were made at the beginning of winter and again in the spring after the plants had wintered.

The condition of the plants was studied by growing the plants in lighted, heated chambers and by comparing the growth of the growing cone under laboratory conditions simulating long days with many hours of daylight with its growth under natural field conditions.

The long days were simulated by lengthening the natural day to 17 hours by use of electric lights, using 550 watts per square meter of area. Differences in the growing cones of the plants were studied with the aid of magnifying glasses and a graph, tracing the plants stages of development.

The plants' resistance to cold was determined by the percentage of the total number of specimens taken from the fields which survived.

The plants in the heated, lighted chambers actually grew. Along with the study of their growth, the percentage of living plants in the total number was determined.

The influence of agricultural technology on winter grains' resistance to cold in the winter and spring was studied by analyzing the condition of the plants before and after provision of wintering facilities under various conditions on the fields of the Institute of Agriculture, in kolkhozes, and in the State Sorting Point of Talovskiy Rayon. Various methods of agricultural technology were utilized in sowing experiments. These experiments entailed differences in the time selected for working the soil under winter sowing conditions, in the actualy sowing date, in the depth of sowing and in the method of conditioning the soil before ~~the~~ sowing.

Cold-resistant varieties of winter wheat were studied under the conditions of the Kamenniy Steppe by freezing the plants before and after thaws.

The observations of the local weather station on temperature and other conditions were accepted. The research staff only used their own observations in the complete absence of any observations by the weather station.

The lack of refrigeration equipment made it necessary to freeze plants under natural conditions.

Plants tested at the beginning of winter were taken out of the ground with the utmost care so as not to harm their roots. These plants were set in containers filled with earth and were ~~set~~ placed both in the open air and inside a greenhouse. Up to 30 plants were set in containers with a diameter of 20 cm. These plants had 4-6 stems each.

Plants set out in the open air were exposed as completely to meteorological conditions as those in the fields.

At root level the temperature was read daily at 7 AM. At the same time, the weather data of the meteorological station was utilized in determining the periods of crop freezing.

At the beginning of winter, as soon as the temperature of the air and of the soil at the root level began to drop sharply, i.e. to 15 to 20 degrees below zero some of the experimental plants were carried into heated, lighted chambers to grow; others were left exposed in the open air for further freezing. Others were set on the ground in open greenhouses for wintering. To prevent these latter plants from freezing completely, their containers were placed in horse manure and the sides were also covered with porous horse manure. When the snow fell, the containers with their plants were covered with snow. The plants were kept under these conditions until spring when they were again examined.

When it became necessary to examine the plants' condition and their resistance to cold, they were taken out, placed in a cool place to thaw, and then put in the heated chambers.

Observations on the development and preservation of cold-resistance in the experimental stock were conducted all winter. After each sharp drop in temperature, the plants from the exposed area, which were kept in little wagons, were carried into the heated, lighted chambers to grow.

Maintenance of cold-resistant qualities in plants was studied by the same method as development of cold-resistant qualities with one distinction. After the plants which had been carried into the heated, lighted chambers had begun to grow, they were subjected a second time to freezing in the open air.

A record of the plants which had survived and of those which had perished was maintained as follows: (1) For a period of 20 days, for plants with a growing temperature of 17 to 20 degrees above zero; (2) For 15 days, for plants with a growing temperature of 25 degrees; (3) For a month, for plants with a growing temperature of less than 15 degrees above zero.

While the plants were growing, the soil was kept humid to insure a more rapid growth of the plants.

CONFIDENTIAL

Requirements in regard to the nature of the work consisted of: (1) timeliness in freezing the plants after their hardening; and (2) accuracy in selecting the proper freezing temperatures after the plants had begun growing.

It was necessary to freeze the plants, both before and after thaws, so that some of the plants which were being compared would be damaged or killed while other plants remained healthy. This freezing had to be maintained through the entire winter.

Results of the Work

The above-mentioned wave of frosts in November, which lowered the temperature on the ground's surface and in the air to 18-20 degrees below zero in the snowless period and to 29 degrees below zero in December under a light snow cover, does not give any information about the frost resistant qualities of winter grains, and, in particular, winter wheat. A determination of the resistance of the plants under field conditions, at the beginning of winter and in the spring after wintering, indicates that the frost-resistance of winter wheat 0237 Gostianum depends, to a large degree, upon the extent to which the soil has been worked, upon the time of sowing, upon the depth of seeding and upon the pre-sowing condition of the soil.

CONFIDENTIAL

Declassified in Part - Sanitized Copy Approved for Release 2012/05/23 : CIA-RDP82-00039R000100040057-5

Table I

Frost Resistance of Winter Wheat Gostianum 0237

Independent of Conditions of Agricultural Technology

Place of Cultivation	Working of the Soil	Time of Seeding	Depth of Sowing in cm	Previous Crop	Percentage of live seeds		
					at beginning of winter	after wintering	protruding
Institute of Agriculture:							
Fields among shelter belts*	black fallow	26/VIII	6-7	barley	97	85	no
Steppe*	" "	30/VIII	6-7	oats	89	57-67	"
Talov State Sorting Point:							
Industrial crops	black fallow	1/IX	5-6	—	97	85	"
Experimental types	" "	1/IX	5-6	—	97	91	"
Kolkhoz imeni Krupskaya	late fallow	20/IX	3	spring wheat	87	70	"
Talov Agricultural Artel	May fallow	1/IX	3-4	spring wheat	86	45	"
	July fallow	20/IX	3-4	barley	27-33	0	"
Kolkhoz "Krestyanskiy Trud"	June fallow	19/IX	6	beets	84	49	"
Kolkhoz "Veseliy Trud"	late fallow before sowing	~~19/IX~~ 19/IX	~~XXXXX~~ 1-2	spring grain	70	43	Yes
Kolkhoz "Novyy Trud"	May fallow	20/IX	1-2	Land idle 6-7 years	50	0	"

*No snow cover over these sections. Show cover over others.

An examination of the data presented in Table 1 clearly reveals differences in plants and in their qualities of resistance.

The Institute of Agriculture provided good conditions for growing winter grain crops on fields among shelter belts and at the Talovskiy State Sorting Point. Proper and timely working of the soil and proper sowing made possible healthy development and better fall rooting of the plants. As a result, the plants went through the winter better prepared, i.e., more resistant to the winter's adverse conditions. At the beginning of winter, winter wheat 0237 Costianum was 97 percent frost resistant on the fields protected by shelter belts, but only 89 percent frost-resistant in the open steppes. When wintering without any kind of snow cover, the plants were only 85 percent and 67 percent, respectively, frost-resistant.

Although there was a snow cover in the kolkhozes "Novyy Trud" and "Veselyy Trud", shallow sowing caused a failure of the winter wheat crop in the 1946/47 winter. The loss of winter wheat in the kolkhoz "Novyy Trud", even at the beginning of winter, was 50 percent; but after wintering of the wheat, the loss was 100 percent. In the kolkhoz "Veselyy Trud" there was a 30 percent crop loss at the start of winter and a 57 percent loss in the spring. Dead seeds which lay on the surface of the ground and never took root were not included in these figures. An investigation into the conditions of wintering of young plants in these kolkhozes showed that there were many plants with protruding roots. The roots of these plants protruded as a result of shallow sowing and late working of the soil before sowing. Protrusion of roots was the principal cause of crop failure.

The principal loss in winter wheat took place on the kolkhoz "Krestyanskiy Trud" because of the late pre-sowing conditioning of the soil and the late date of sowing. In this kolkhoz, the number of plants still living after the first frosts of winter was only 84 percent. By the end of winter, only 49 percent of the total number of plants were still alive.

The date of sowing also had great significance in the development of frost-resistant winter wheat as was shown by the sowing in the kolkhoz "Talovskiy Agricultural Artel".

A study of frost-resistant qualities of young plants sown on 1 and 20 September revealed big differences in the resistance of these plants. The loss of the plants sown on 1 September was 14 percent at the beginning of winter after the November and December frosts while the loss of the plants sown on 20 September came to 70 percent. After wintering, the plants planted on 1 September suffered a loss of 45 percent. Those planted on 20 September suffered a 100 percent loss.

Preparation of the soil before winter wheat sowing is also important in developing frost-resistant plants. If one compares the frost-resistance of winter grains during the same periods, in the kolkhoz "Veselyy Trud", where the ground had lain fallow, and in the kolkhoz "Novyy Trud", where the soil had not been worked for 6-7 years, it is apparent that the resistance to frost of the plants was less on the kolkhoz "Novyy Trud".

To sum up, the main reason for the loss of winter wheat crops in the 1946-47 winter, under conditions of the central chernozem belt, was the non-observance of proper agricultural technology on many farms. Late pre-sowing conditioning of the soil and shallow surface-planting of the seeds led to the exposure of some of the seeds on the surface and to the protrustion of roots. When the sowing was done late, the plants took root, bushed poorly, and did not harden satisfactorily.

When the land that had been idle many years was plowed in May rather than in the previous autumn, the resultant late sowing led to tardy growth and imperfect hardening of the plant which then became less able to resist frost. The fact that plants planted in long idle land were less frost resistant than those planted in fallow land is explained by a disproportion of nitrogen, phosphorous and potassium in the soil. A surplus of nitrogen leads to a lowering of the plant's resistance to frost. Poor conditions in the early stages of a plant's growth and development lead to low frost-resistant qualities in the plant and to its eventual damage and loss.

The Effect of Winter Damage on the Life Expectancy of Plants

Winter damage occurring at lower temperatures lowers the life expectancy of a plant. Plants suffering most damage in winter, develop slowly, mature late, and are of poor quality. They usually produce a smaller harvest.

Plants taken from the steppe were less vigorous than those taken at the same time from the fields protected by shelter belts. The plants protected by shelter belts, as well as those from the steppes which lacked snow, were damaged much more by the lower temperatures.

The harvest of damaged crops was small, and the most damaged crops produced no harvest at all.

Apparently, the growing conditions of the plant in the first stage of its development has a great influence on its life expectancy and productivity.

Conditions of Winter Wheat and Rye and Reasons for their Freezing

In 1935, Kuperman agreed with the contention of the author (made in 1934, 1935) that a high sugar content in the plant does not always insure a high degree of frost-resistance. An increase in the formation of soluble carbo-hydrates in the plants often causes a decrease in their frost-resistant qualities. According to data of Krasovskiy (1946), a low sugar content in the plants coincides with decreased resistance to lower temperatures.

Although extensive research has been undertaken to establish relationships between the frost-resistant qualities of plants and their internal physico-chemical characteristics, this work could not be made the basis for the plant geneticists to discover frost-resistant crops nor for the agronomist to develop improved methods of sowing. I. V. Michurin developed new trends in the solution of problems of frost-resistance by plants and T. D. Lysenko expanded Michurin's ideas. Their work proved that the plant organism could be controlled by controlled breeding.

Although control over the plant's growth and stages of development can even change the plant's resistance to frost, insufficient study of the conditions of development of these processes in the winter-spring period have so far been a barrier to further study. Depending on the conditions of growth and development, these processes take different forms.

Table 2

Wintering of Plants under Field Conditions

Name of crop and type	Percentage of Plants Surviving at the time Specimens Were Taken from the Field for Examination												
	23/XI	4/XII	6/XII	12/XII	23/XII	28/XII	Average for January	20/I	12/II	26/II	Average for February	18/III	3-14/III
Winter rye:													
VSKhI	100	100	100	97	90	91	92	100	85	77	81	64	73
Mup	100	100	100	98	93	94	98	100	100	68	84	73	81
Winter wheat:													
Steppe 135 protected by shelter belt	100	93	100	97	91	97	96	100	90	88	89	85	83
Gostianum 0237 protected by shelter belt	100	89	100	93	97	99	97	100	100	88	89	85	83
Gostianum 0237 on open steepe	100	83	100	89	91	93	76	57	67	57	67	57	77

Table 2 reveals that by the end of February the following percentage of crops were still alive: winter rye: VSKhI - 81 percent, Mup - 84 percent; winter wheat: Steppe 135 - 89 percent, Gostianum 0237 protected by shelter belts - 89 percent, and on steppes - 67 percent. By March, the number of living plants had decreased as follows: VSKhI from 81 to 64 percent; Mup from 84 to 73 percent.

A severe drying of the soil during the winter sowing periods, the presence of continual overcasts and rainy days during autumn growing periods, and the periodic increases in temperature in autumn when the plants harden, not only prevent the plants from developing sufficient frost-resistance, but, during the periodic thaws, even cause a loss in the frost-resistance already acquired.

Weather conditions during the period from sowing to the coming of winter form a basis for assuming that the stage of vernalization of the winter grain plants was terminated before winter.

An examination of the growing cone of winter wheat and rye plants at the beginning of winter revealed a longer and more differentiated growing cone for these plants, particularly for the rye, than is usually found in these plants.

To prove these contentions, plants were dug up from the fields at the beginning of winter and were transplanted in containers which were then placed in heated, lighted chambers. All the winter wheat and rye plants formed spikes, indicating that they had passed through the vernalization stage.

The resistance to frost of winter grain plants of the central chernozem belt under conditions of the 1946/47 winter depended mainly on the extent of their hardening during autumn and the degree to which they had preserved their resistance during the winter and spring thaws.

In tests taken before January, the following results were observed: VSKhI winter rye - 92 percent of the plants remained alive, Mup - 98 percent; of the winter wheat, 135 Steppe - 96 percent remained alive;

0237 Gostianum planted in the shelter belts - 96 percent, and in the steppe - 90 percent. The very highest percentage lost during this period was on the steppe - 10 percent. On the fields protected by shelter belts, only 2 to 4 percent was lost.

An investigation of the frost-resistant qualities of the plants in the middle of January, after a severe drop in ground surface temperature at the beginning of the month (up to 33 degrees below zero), indicated that the loss during this period did not exceed 10 percent. More serious losses of all types of rye and wheat took place near the end of February, especially, at those points where the snow had melted during the thaws (Table 2). For example, 19 percent of the total crop of VSKhI winter rye froze; but in places without snow cover, this figure reached 23 percent. For Mup, these figures were, respectively, 16 and 32 percent; for 135 Steppe, 11 and 12 percent; for 0237 Gostianum, 11 and 12 percent in fields protected by shelter belts; and 33 and 34 percent on the steppe.

March frosts of from 12 to 18 degrees below zero, coming after a rather long warm period at the end of February, and high temperatures during the first days of March, again caused damage and loss to plants.

The number of VSKhI winter rye plants which survived decreased to 64 percent; of Mup, to 73 percent. The resistance of the winter wheat to this marked drop in temperature was not observed.

Table 3

No. of Live Plants and Stems per Square Meter

Name of plant and type	4th April alive		12th June alive		Destroyed during period - April through June		Percentage of destruction from April to June	
	plants	stems	plants	stems	plants	stems	plants	stems
Winter Rye:								
VSKhI	168	664	142	552	26	112	19	17
Mup	204	673	186	653	18	20	9	3
Winter wheat:								
135 Steppe protected by shelter belt	194	588	111	389	83	169	42	30
0237 Gostianum protected by shelter belt	223	579	154	488	69	91	31	16
0237 Gostianum on steppe	222	444	220	465	2	—	1	—

By calculating the number of plants surviving per unit of area, it is possible to show the extent of the overall damage and freezing of the plants and stems during the spring period (April, May). After the number of plants and stems surviving per square meter at the beginning of April was determined, further examination was made in June. At that time, plant loss was found to have been considerable.

During the April and May frosts, which followed a long thaw, both the plants and the stems suffered. Of the rye, the type that suffered most was VSKhI; and of the winter wheat, 136 Steppe. In this period there was greater damage done to the plants in fields protected by shelter belts than on the steppe.

The great damage done to the plants on the steppe during low winter temperatures in comparison with those sown between the shelter belts resulted from the tardier growth and development of the plants on the steppe. Observation under field conditions of plants protected by shelter belts and of those on the steppe during the spring thaws proved that the growth of the plants and the formation of their embryonic spikes during the spring thaws began earlier in the plants protected by shelter belts than in those on the steppe.

The earlier formation of embryonic spikes on the winter wheat plants of the fields protected by shelter belts than on the plants of the steppe was the result of lesser damage to the protected plants from spring freezing and subsequent thaws. Meteorological conditions of 1946/47 help to explain the differences in the development of the two sets of plants. The more intense freezing and slower thawing of the soil in the steppe was responsible for the slow growth and development of the steppe winter wheat and retarded development of the embryonic spikes.

The late frosts in March, April and, especially, in May, which lowered the temperature of the air to 8 to 10 degrees below zero, coming after thaws which had reached 18 degrees above zero in March, 21 degrees above in April, and 24 degrees above in May, had little affect on the frost resistant plants. The plants, at the end of March and at the beginning of April began to take on foliage. A more vigorous growth of leaves and stems, and even the formation of new shoots, began after 20 April. The growing cone of the plants also developed during the thaws. It lengthened, became covered with rings and passed from one stage into another. Embryonic spikes began to develop on many plants and stems.

An analysis of the development of the embryonic spikes of the different types of grain during the warm periods indicated that this development did not take place simultaneously in all plants. The winter wheat Zernogradka formed its embryonic spike earlier than did 135 Steppe, but 135 Steppe was earlier than 0237 Gostianum. The earlier development of the embryonic spike of 135 Steppe during the spring thaws led to a considerable loss of plants and stems from the freezes which followed the warm spells (Table 3).

The studies of many scientists have demonstrated that the formation of the embryonic spike greatly decreases the plant's resistance to frost. Plants, which were capable of enduring low temperatures of 16 to 20 degrees below zero before the formation of the embryonic spike, froze at 7 degrees below zero after its formation.

After a frost of 8 to 10 degrees below zero following the development of the embryonic spike, those stems which had already developed embryonic spikes died out, but at the same time new stems were formed. As a result of these phenomena - the loss and disappearance of the dead plants and stems which had perished in the winter and early spring periods, and the formation of new stems in the spring period - an examination of the plants which survived did not completely reveal the extent of the spring crop loss, especially the losses in April. Therefore, as is evident from the data on the surviving plants and stems per square meter (Table 3), the fact that these plants were dying was not reflected in the April tests even though noted in the overall records on the sowing of winter grain.

It seems certain that the thaws at the end of autumn and at the beginning of winter were responsible for the plant's poor development and low frost-resistance. The winter grain plants entered the winter insufficiently hardened. During the fall and winter thaws, growing cones developed on the plants which had passed through the stage of vernalization and as a result the plants hardened more slowly.

The low temperatures of December and January, although not winter-killing the plants, greatly damaged and weakened them. After the frosts, a considerable part of the plants' leaves turned yellow.

Further severe frosts in February, during a period when there was a sparse snow cover and when the plants were insufficiently hardened, again damaged many of the plants and killed off the weak ones.

Periodic thaws at the end of February and in March and a rather significant temperature rise in April and May caused more rapid development of the growing cone and the embryonic spike. As a result, the plants were damaged and weakened by subsequent frosts.

Different types of plants reacted differently. Some were damaged more than others. These differences occurred in various types of plants and in individual plants among the various stems.. Some of the plants perished while others survived. Some stems were frozen while others on the same plant went undamaged.

Up to the present time, it has been assumed that differences in the characteristics of plants of the same type are due to a lack of homogeneity and to physiological differences, in particular, in the plant's resistance to cold. The reasons for the differences were not indicated.

A study of the development of the growing cone under field and laboratory conditions for the autumn, winter and spring periods showed variations in growth and in the development of the embryonic spike, both in different types and varieties of plants and in the various stems of the same plant.

Differences in the growing cones account for the varying degrees of endurance of the plants after thaws. The greater the development of the growing cone, the less the plant will develop and maintain its resistance to frost. When the embryonic spike is formed, or when the plant passes from the stage of vernalization into a new form, its frost-resistance falls sharply.

Table 4

Frost Resistance of Plants Which Have Gone through the Vernalization Stage after Their Growth under Diverse Conditions

Type	Percentage of Plants Surviving			
	Natural daylight	17 hours of daylight	Field conditions	
	Heated chambers		January average	March
Winter Rye:				
VSKhI	20	0	92	64
Mup	42	0	98	73
Winter Wheat				
Gostianum 0237, protected by shelter belts	66	0	97	85
Gostianum 0237, open steppe	66-	0	90	57
Steppe 135, protected by shelter belts	60	0	96	85

The conduct of the 1946-47 experiments in the study of resistance to frost by plants which had gone through the vernalization stage after their growth under diverse conditions of light and warmth again indicated the sharp differences among the various types of plants and within each type (Table 4).

After the plants were grown in a warm place with 17 hours of light daily, a subsequent freeze caused their complete destruction. Plants grown under the same conditions but with natural daylight suffered less damage. The complete loss of plants which had received 17 hours of light daily was explained by the development of the embryonic spike on the plants and by a consequent extreme lowering of their resistance to frosts during this period of their development. The significant losses among plants grown under conditions of natural daylight, but in heated chambers, when compared with those grown in the fields, was explained by the greater development of the growing cone of the former. Greater development in the embryonic spike led to more rapid freezing and to more serious damage to the stem.

Meteorological conditions during the early spring period of 1947 were very favorable for the growth and development of winter grains in the area under consideration. Significant thaws which might have caused rapid growth of the plants were not observed. But the temperature of the air and the ground surface did reach 21 to 24 degrees above zero in May with a subsequent drop in temperature to 8.5 degrees below zero. However, this temperature drop did not greatly affect the plants because at this time the warmth during the day was accompanied by a cooling of the soil during the night and early morning. As a result, the growth and development of the plants was not great; the development of the embryonic spike was retarded; and the frost resistant qualities were maintained in the plant. All these factors in turn saved the plants from the more severe frosts.

Conclusion

From the above evidence, it can be assumed that the yearly conditions of the central chernozem belt are such that many of the winter grain plants go through the vernalization stage between the time of sowing and winter. The presence of late autumn and winter thaws during the latter half of the vernalization stage speeds up development of the growing cone. The growing cone grows in length and is covered by more rings.

Under these conditions, the plant not only does not harden, but actually often suffers a decrease in frost resistance. During the more significant thaws when the plants begin growing rapidly, they may develop an embryonic spike. With the formation of this embryonic spike, the plants undergo qualitative changes and are almost completely unable to resist frost.

Differences in the frost-resistant qualities of different types of plants and of stems within the same plant are explained not only by the differences in the development and maintenance of frost-resistant qualities during the stage of vernalization, but also by the dissimilar development of the growing cone and the embryonic spike after the conclusion of the vernalization stage. As a result, the various plants' resistance to frost diminishes during thaws in different ways and to different extents. With the development of the embryonic spike, the frost-resistance of the plant becomes extremely low. However, no matter how variable may be the frost-resistance of different plant varieties and of stems of the same plant, and no matter how varied the plants in their independence in regard to growing conditions, the characteristics of heredity make possible the differentiation of plants with greater frost-resistance from those less frost-resistant.

The frost-resistance of grains is determined, primarily, by their growth and development during the winter and spring period. In order to prevent loss and serious damage to the plants from frosts following the winter and spring thaws, it is necessary to delay the processes of growth and development during these thaws. First, the breeding of types which require many hours of daylight and high temperatures for the growth and development of the embryonic spike and, secondly, the control of the water and heat content of the soil, of the height and density of the snow cover, of the appropriate working of the soil and of the spreading of manure, can secure good wintering and high harvests from winter crops.

CONFIDENTIAL

BIBLIOGRAPHY

1. Vetukhova, A. A. - Reports of Acad Sci, USSR, Vol. 4, no. 1, 1946.
2. Golush, B. M. - Reports of Acad Sci, USSR, Vol. II, no. 3-4, 1935.
3. Zhuravlev, M. M. - Resistance of Winter Wheat Types to Freezing under Western Siberian Conditions, Puti Sel'skogo Khozyaystva (Paths of Agriculture), No. 10, 1928.
4. Kolkunov, V. V. - Loss of Winter Grain and Measures for Prevention of Loss, 34th supplement to Trudy po Prikladnoy Botanike, Genetike i Selektsii (Works on Applied Botany, Genetics, and Selection), 367-371, 1929.
5. Krasovskaya, I. V. - Physiological Bases of Frost Resistance in Winter Wheat under Conditions of Gorkiy Oblast, Acad Sci, USSR, Vol. 4, no. 1, 1946.
6. Kuperman, F. M. and Zadontsev, A. I. - Reasons for the Loss of Winter Crops during the Ukrainian Winters of 1931-1932 and 1933-34. Trudy po Prikladnoy Botanike Genetike i Selektsii, Vol. 3, no. 6, pp. 97-120, 1935.
7. Kruzhilin, A. S. - Physiology of Irrigated Field Crops, pp. 1-274, Sel'khozgiz, Moscow, 1944.
8. Maksimov, N. A. - Freezing and Plants' Resistance to Cold, Izvestiya Lesnogo Instituta (Herald of the Forestry Institute), 25, pp. 1-330, 1913.
9. Maksimov, N. A. - Trudy po Prikladnoy Botanike, Genetike i Selektsii, 22, 1929.
10. Mosolov, V. P. - The Problem of Winter Crop Losses, Nauchno-ekonomicheskiy Zhurnal (Journal of Science and Economics), No. 2, 1928.
11. Mosolov, V. P. - Agricultural Technology in the Fight against Winter Grain Losses, pp. 1-207, Tatgoizdat, Sector of Agricultural Literature, Kazan, 1934.

CONFIDENTIAL

12. Rikhter, A. A. and Grechuskhnikova, A. I. - Physiological Processes Causing Losses of Winter Grain by Smothering under an Icy Crust, Acad Sci, USSR, Vol. 3, p . 391-408, 1932.

13. Rikhter, A. A. - Research on Frost Resistance of Plants; Dunamics of the Soluble Carbohydrates of Wheat and Rye during the Winter Period, in the journal Opytnaya Agronomiya Yugo-vostoka (Experimental Agronomy of the Southeast), Vol. 2, pp. 1-4, 1927.

14. Tumanov, I. I. - Physiological Bases of Crops' Resistance to Frost, Sel'khozgiz, State Publishing House of Kolkhoz and Sovkhoz Literature, pp. 1-365, 1940.

- END -